Society for the Study of Economic Inequality

Working Paper Series

# Transport consumption inequalities and redistributive effects of taxes: A comparison of France, Denmark and Cyprus

Akli Berri
Stéphanie Vincent Lyk-Jensen
Ismir Mulalic
Theodoros Zachariadis

ECINEQ WP 2010 – 159

ECINEQ 2010-159
February 2010

www.ecineq.org

# Transport consumption inequalities and redistributive effects of taxes: A comparison of France, Denmark and Cyprus

**Akli Berri***
*INRETS, Department of Transport Economics and Sociology (DEST)*

**Stéphanie Vincent Lyk-Jensen**
*SFI - The Danish National Centre for Social Research*

**Ismir Mulalic**
*University of Copenhagen and Technical University of Denmark*

**Theodoros Zachariadis**
*University of Cyprus*

**Abstract**

We evaluate household transport consumption inequalities in France, Denmark and Cyprus, investigate their temporal dynamics and estimate the redistributive effects of taxes on different commodity categories. A comparative analysis is carried out in light of the differences between these countries, most notably in terms of car taxation systems and car ownership levels. A decomposition by expenditure component of the Gini index is applied, using household-level data from repeated cross-sections of expenditure surveys spanning long time periods. The results highlight the effect of car social diffusion. The relative contribution of vehicle use items to total expenditure inequality decreases over time, thus reflecting the more and more widespread use of the car. Moreover, fuel taxes become regressive (i.e. they affect the poor more than the rich), while the progressive character of taxes on the remaining car use commodities weakens with time. Taxes on transport goods and services as a whole are progressive (i.e. they affect the rich more than the poor). However, this is principally due to the progressivity of taxes on automobile purchases. The progressivity of taxes on car purchases is by far much stronger in Denmark. In this country, these taxes are so high that car purchase costs can be afforded only by high incomes. These findings underline the fact that equity issues should not be overlooked when designing policies to attenuate the environmental impact of cars. Increasing car use costs, notably fuel prices, through an increase of uniform taxes would be particularly inequitable.

**Keywords:** Inequality; transport consumption; household expenditure surveys; Gini index; decomposition by component; redistributive effects of taxes
**JEL classification**: D12, H23, H24, R41.

---

* **Address of correspondence:** Address of correspondence: 2, rue de la Butte Verte, 93166 Noisy-le-Grand cedex, France. Tel.: +33-(0)1-4592-5586. Fax: +33-(0)1-4592-5501. Email: akli.berri@inrets.fr

## 1. INTRODUCTION

Car taxes are a source of public revenues as well as a policy tool to reduce adverse impacts of road traffic. Most of them were instituted in a time where the car was a luxury good (e.g. the French *vignette*, an annual tax on vehicles owned, in 1956; registration tax in Denmark as early as 1924). The large social diffusion of this good over the past decades has doubtless lessened the progressivity of these taxes. The protests in several European countries against the rapid increase in fuel prices during autumn 2000 highlighted the sensitivity to the burden of fuel costs, not only of professionals but also of households, particularly those in rural and suburban areas who are more car-dependent.

In this paper, we evaluate inequalities between households regarding the consumption of transport goods and services in France, Denmark and Cyprus, investigate their temporal dynamics and estimate the redistributive effects of taxes on the different commodity categories considered. A comparative analysis is carried out in light of the differences between these countries, most notably in terms of car taxation systems and car ownership levels. Consumption is measured in terms of expenditures collected through budget surveys. As Deaton (1997) puts it, by revealing who buys each good or service and the amounts spent, expenditure surveys tell us who bears the most of the corresponding taxes (notably, according to income level) and thus the potential losers and gainers from possible changes in taxation.

The analysis applies a decomposition of the Gini inequality indicator by expenditure component. Each component appears through its proper Gini coefficient, its budget share and its degree of association with total expenditure. This method provides a better understanding of the inequality mechanisms, in particular their temporal evolution. Moreover, it allows evaluating the redistributive effect of (a change in) a tax on a good or a service. By *redistributive effect*, it is meant the impact in terms of inequality increase or reduction. Finally, it furnishes estimates of elasticities with respect to total expenditure (or income) without specifying a functional form for the Engel curves.

The data are from repeated cross-sections of household expenditure surveys. For each country, a few distant survey periods (about 10 years apart) are selected among the accessible data sets: three for France (1978-79, 1989 and 2000-01), two for Cyprus (1991 and 2003), and two for Denmark (1997 and 2005). The number of surveyed French households is of 10,645 in 1978-79, 9,038 in 1989 and 10,305 in 2000-01. In Cyprus, the sample is comprised of 2,708 households in 1991 and 2,990 households in 2003. For Denmark, there are observations for 881 households from the 1997 survey and 725 households from the 2005 survey.

After an exposition of the methodology of Gini decomposition by expenditure component in the next section, Section 3 presents some of the characteristics of the car taxation systems in the three countries and examines the budget shares allocated to different expenditure groups according to household's standard of living. Section 4 presents the results of the analyses of inequality and redistributive effects of taxes on the different categories of goods and services considered. The last section summarises the findings and concludes.

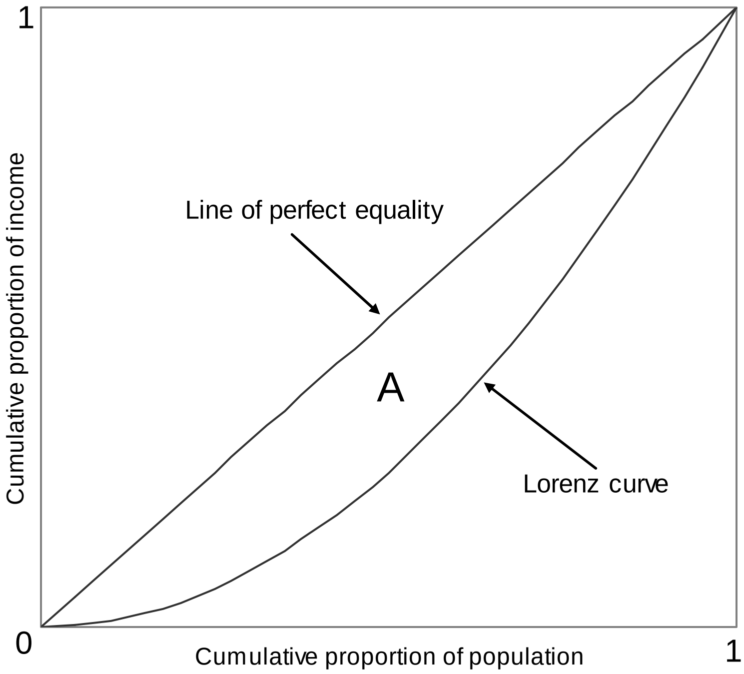
## 2. DECOMPOSITION OF THE GINI COEFFICIENT BY COMPONENT AND REDISTRIBUTIVE EFFECTS OF MARGINAL CHANGES IN COMPONENTS

### 2.1. The Gini Inequality Index

The Gini coefficient is one of the more widely used indicators to evaluate inequalities (of income, wealth, consumption…). A graphic visualisation of this index is based on the Lorenz curve, shown in Figure 1. The Lorenz curve of income, for instance, is constructed by arranging individuals from the poorest to the richest, and then representing their cumulative share of total income as a function of their cumulative proportion in the population.

If each individual had the same income, the curve would coincide with the main diagonal, the income share of a given group being equal to its weight in the total population. Apart from the case of perfect equality, the groups with the lowest incomes enjoy a share of total income that is lower than their weight in the population. Consequently, except in the case of perfect equality, every Lorenz curve lies below the main diagonal and its slope increases (in any case, it does not decrease) as one moves towards the highest incomes.

Figure 1. *Illustration of a Lorenz curve*




This graphic tool plays an important role in the characterisation of the robustness of inequality measures as to ranking distributions (Atkinson, 1970; Deaton, 1997). Thus, if the Lorenz curve of a distribution $Y$ lies everywhere below that of another distribution $X$, $Y$ is less egalitarian than $X$. Indeed, the distribution $Y$ can be transformed by a series of transfers from the richer to the poorer in such a way to obtain the distribution $X$. Consequently, when two Lorenz curves do not cross, the upper one represents a more egalitarian distribution and will show a lower inequality level provided the inequality measure used satisfies the *principle of transfers*. The *principle of transfers* is stated as follows: if one transfers an amount $d$ from a person having an income $y_1$ to another person having a lower income $y_2$ (with $y_2 \leq y_1 - d$, such that the transfer does not reverse their relative positions), then the new distribution should be preferred to the initial one. In the case where two Lorenz curves intersect, it is not possible to rank unambiguously the corresponding distributions as to their degree of inequality, unless restraining choice to specific inequality measures.

The Gini coefficient is defined as the ratio of the area between the Lorenz curve and the main diagonal (designated by A in Figure 1) to the area of the triangle below the diagonal (i.e., $1/2$), that is $G = 2A$. When the distribution is perfectly egalitarian, its Lorenz curve coincides with the diagonal, hence $A = 0$ and $G = 0$. Absolute inequality implies that $A$ is the whole area of the triangle under the diagonal, so $A = 1/2$ and $G = 1$. Thus, the Gini coefficient takes values between 0 and 1.

One of the appeals of the Gini coefficient as a measure of (income) inequality is that it is "*a very direct measure of (income) difference, taking note of differences between* every *pair of (incomes)*" (Sen, 1997, p. 31). Indeed, one of its expressions (the original definition) is based on the *average of absolute differences between pairs of observations*, called *Gini's Mean Difference* (GMD):

$$\frac{1}{N^2}\sum_{i=1}^{N}\sum_{j=1}^{N}\left|y_i - y_j\right|,$$

where $y_i$ is the income of individual $i$ and $N$ is the number of individuals in the population.

The Gini coefficient is defined as the GMD divided by twice the mean ($m$):

$$G = \frac{1}{2N^2 m}\sum_{i=1}^{N}\sum_{j=1}^{N}\left|y_i - y_j\right|. \tag{1}$$

Another convenient feature of the Gini coefficient is that it handles negative values, which is in particular useful in its decomposition by income source, where taxes are considered as "negative incomes" (Lerman and Yitzhaki, 1994).

Besides equation (1), the Gini coefficient has several expressions (Sen, 1997). In the following, we adopt a formulation that is easy to implement directly on individual data. This formulation is used to obtain a decomposition by the constituents of the variable of interest. The decomposition makes explicit the mechanisms by which each component contributes to the global Gini and therefore enlightens the temporal patterns of inequalities. Besides, it enables evaluating the redistributive effects of taxes on the different components.

## 2.2. A Practical Formulation of the Gini Coefficient

Lerman and Yitzhaki (1984) show that the Gini coefficient can be expressed as a function of the covariance between the variable of interest ($X$) and its cumulative distribution ($F_X$), and of its mean ($m$):

$$G(X) = \frac{2\operatorname{cov}(X, F_X)}{m}. \tag{2}$$

Estimation of the Gini coefficient using this formulation is easy to implement on individual survey data. Indeed, one only has to estimate the mean of $X$ and the covariance between $X$ and its empirical cumulative distribution, and to substitute for the corresponding terms in the expressions above. With a random sample (same selection probability for all individuals) of size $n$, the cumulative distribution is estimated by ranking individuals according to increasing values of $X$ and by dividing their ranks $i$ by the sample size, i.e. $\tilde{F}_X = I/n$, and the mean is estimated by $\tilde{m} = \sum_i x_i \Big/ n$. In the case of a non-random sample (selection probability varying from one individual to another), the observations have to be weighted by the respective individual survey weights, $w_i$. The cumulative distribution and the mean of $X$ are estimated as follows:

$$\hat{F}_i(x) = \sum_{j=0}^{i-1}\pi_j + \frac{\pi_i}{2}, \text{ with } \pi_0 = 0, \text{ and}$$

$$\hat{m} = \sum_{i=1}^{n}\pi_i x_i ,$$

where $\pi_j = w_j \Big/ \sum_{i=1}^{n} w_i$.[1]

[1] A derivation of $\hat{F}_X$ can be found in (Berri, 2005), pp. 246-248.

By avoiding the usual practice of grouping data prior to estimation, this approach yields estimates that are more accurate and free of the (downward) bias due to aggregation. Lerman and Yitzhaki (1989) show that this bias increases with the aggregation level and with the value of the Gini coefficient.

### 2.3. Decomposition of the Gini Coefficient by Component

This covariance-based formulation is used by Lerman and Yitzhaki (1985) to obtain a decomposition of the Gini coefficient by the constituents of *X* and apply it to the analysis of the effects of income sources on the global income inequality. Garner (1993) applies it to the analysis of inequalities in terms of expenditures.

Consider the case where $X$ is household's total expenditure. Let $x_1, x_2, ..., x_k, ..., x_K$ be the amounts spent on the $K$ budget components, such that:

$$X = \sum_{k=1}^{K} x_k . \tag{3}$$

Then, using the additivity property of covariance, the Gini coefficient of $X$ can be written:

$$G(X) = 2\sum_{k=1}^{K} \frac{\text{cov}(x_k, F_X)}{m} . \tag{4}$$

Let $F_k$ and $m_k$ be the cumulative distribution and the mean of $x_k$, respectively. Multiplying and dividing each term in $k$ in equation (4) by $\text{cov}(x_k, F_k)$ and by $m_k$, one obtains the decomposition by component:

$$G(X) = \sum_{k=1}^{K} \left[ \frac{\text{cov}(x_k, F_X)}{\text{cov}(x_k, F_k)} \right] \times \left[ \frac{2\,\text{cov}(x_k, F_k)}{m_k} \right] \times \left[ \frac{m_k}{m} \right]. \tag{5}$$

Denoting the first term of the sum by $R_k$, the second by $G_k$, and the third by $S_k$, the Gini coefficient can be written:

$$G(X) = \sum_{k=1}^{K} R_k G_k S_k , \tag{6}$$

where $R_k$ is the *Gini correlation coefficient* between expenditure *k* and total expenditure, $G_k$ is the Gini coefficient of component $k$, and $S_k$ is its budget share. A high Gini correlation for a category of goods and services means that expenditure devoted to this category is higher the higher the total budget. Gini correlation is a measure of association based on Gini's Mean Difference (Schechtman and Yitzhaki, 1987). The Gini correlation between two variables takes values between –1 and 1. It is equal to zero if the two variables are independent. For example, if one of the variables is a monotonously increasing function of the other, their Gini correlation will be equal to 1. Further details can be found in the Annex.

Thus, the contribution of an expenditure category to total inequality is determined by three terms: its proper Gini coefficient, its average budget share and the degree of its association with total expenditure (measured by their Gini correlation). The higher the value of each of the factors, the stronger is the contribution of the category to total inequality. The expression of the contribution means also that a high Gini coefficient does not guarantee a large contribution to total inequality. As will be seen below, because of a very low budget share the contribution of the item "two-wheeler purchases" is the lowest among the categories considered, though its Gini coefficient is the highest.

This approach is advantageous in that it furnishes a decomposition of inequalities into elements easily interpretable and helps understanding their temporal evolution by examining the evolution of the elements involved in the contribution of each component. Moreover, it avoids a major shortcoming of the usual method called *before-after*. The latter consists in calculating an inequality index after excluding a particular component and comparing it with the value of the index when this component is included. The results of this method may depend on the order in which the components are considered. For instance, in the case of two income sources, Lerman (1999) shows that a component will appear reducing inequalities or, on the contrary, increasing them according to whether one accounts for it before or after the other component.

### 2.4. Redistributive Effects of Marginal Changes in the Components

Another advantage of this decomposition is that it allows evaluating the redistributive effects of marginal changes in the different expenditure categories. It has to be noted that no explicit income transfer is considered here. The expression 'redistributive effect' refers to the impact in terms of increase or reduction of inequality.

Suppose that the expenditure on a particular item $k$ undergoes a small percentage variation, $e_k$, identical for all households (e.g. a tax), such that $x_k\left(e_k\right)=\left(1+e_k\right)x_k$, $e_k>0$. In terms of variation of a tax $t_k$ on expenditure $k$, one has $x_k\left(dt_k\right)=\left(1+dt_k\right)x_k$. The initial rate $t_k$ does not appear, its effect being incorporated in the observation on $x_k$. The tax change is imposed on the expenditure made, $x_k$, which is equivalent to a tax proportional to the price paid by the consumer. The effect on the global Gini is (Stark *et al.*, 1986):

$$\frac{\partial G}{\partial e_k}=S_k\left(R_kG_k-G\right), \tag{7}$$

the terms $S_k$, $R_k$, $G_k$ and $G$ being evaluated before the marginal variation in component $k$ takes place. Dividing by $G$, one obtains

$$\frac{\partial G/\partial e_k}{G}=\frac{R_kG_kS_k}{G}-S_k. \tag{8}$$

Equation (8) shows that the relative variation of the global Gini due to a small variation in expenditure on component $k$ is equal to the relative contribution of the component to overall inequality minus its contribution to total expenditure. The sum of all relative marginal effects equals 0. Multiplication by $1+e$ of all components leaves the overall Gini unchanged. It is also evident that, as long as the budget share $S_k$ is not zero:

A. the relative marginal effect is *negative* if the Gini correlation between expenditure $k$ and total expenditure is negative or null ($R_k\le 0$);
B. if the Gini correlation is positive, the impact on inequality depends on the sign of ($R_kG_k-G$). A necessary condition for this term to be positive is that the inequality of component $k$ exceeds that of total expenditure: $G_k>G$ (since $R_k\le 1$).

Equation (8) defines the concept of *progressivity* used here (Yitzhaki, 1997). A tax will be called *progressive* if an increase in this tax (or its imposition if it does not exist yet) reduces inequality of total expenditure (after taxes). A tax will be called *regressive* if it increases total inequality. This definition can also be justified as follows. Consider the compensation that is necessary to preserve the level of well-being enjoyed by each household before the modification in taxation. If the compensation is progressive (i.e. its share increases with total expenditure or income), the change in the tax affects the rich more than the poor. The tax is then progressive and its increase (or its imposition) will yield a decrease in inequalities. Conversely, if the compensation is regressive (i.e. its share decreases when total expenditure increases), the modification in the tax affects the poor more than the rich. The tax is therefore regressive and its increase (or its imposition) will induce an increase in inequalities.

If the expenditure component is a *decreasing* function of total expenditure (or income), as is the case of a *regressive* tax paid by all households, then its Gini correlation with total expenditure is -1 and the relative marginal effect is *negative*. Consequently, when the relative marginal effect is negative, the taxation should increase inequalities, as would a regressive tax do. If the component is an *increasing* function of total expenditure, as for a *progressive* or *proportional* tax, then its Gini correlation with total expenditure is +1. One is then in the configuration (B) above, and the sign of the relative marginal effect depends on the quantities $R_k$, $G_k$ and $G$.

Hence, the interpretation of equation (8) in terms of the impact on total inequality of (an increase of) a tax on an expenditure category $k$ is as follows: when the relative marginal effect is positive (negative) the taxation should reduce (increase) global inequality. Such a tax would be progressive (regressive).

Besides, the decomposition described above provides estimates of elasticities (called *Gini elasticities*) with respect to total expenditure without specifying a functional form for the Engel curves. The term

$$\eta_k = \frac{R_k G_k}{G} = \frac{\operatorname{cov}(x_k, F_X)}{\operatorname{cov}(X, F_X)} \times \frac{m}{m_k} \tag{9}$$

can be interpreted as the elasticity of expenditure $k$ with respect to total expenditure. Indeed,

$$\beta_k = \frac{\operatorname{cov}(x_k, F_X)}{\operatorname{cov}(X, F_X)} \tag{10}$$

can be seen as a non-parametric estimator of the marginal propensity to spend on the category of goods and services $k$ (Olkin and Yitzhaki, 1992; Yitzhaki, 1994).

Notice that the relative marginal effect in equation (8) can also be written as:

$$\frac{\partial G/\partial e_k}{G} = S_k(\eta_k - 1)\,. \tag{11}$$

Equation (11) makes even more immediate the interpretation of the relative marginal effect, in agreement with the usual classification of taxes according to elasticities with respect to income. A tax is progressive if it is imposed on a luxury commodity ($\eta_k$ >1), in which case the relative marginal effect is positive. It is regressive if it is imposed on a necessary or inferior good ($\eta_k$ <1); in this case, the relative marginal effect is negative. However, the extent of the relative marginal effect depends on the magnitude of the component's budget share ($S_k$). Finally, the tax is neutral if the elasticity is equal to 1 (the relative marginal effect is zero).

## 3. TRANSPORT EXPENDITURES IN THE HOUSEHOLD BUDGET

This section describes the budget shares of different transport items by standard of living and their temporal pattern. Households are grouped into quintiles of total expenditure, deflated by the number of consumption units (CU) to account for their composition. The number of CUs in a household is determined according to the Oxford scale: 1 for the reference person (or head), 0.7 for any other member aged 14 or older, and 0.5 for each child of less than 14 years of age. The choice of total expenditure as a classifying variable is justified by the fact that expenditure data are more reliable than income data in budget surveys. On the other hand, a measure based on consumption (more precisely, expenditures) is more relevant than a measure based on income to give an account of the level of material well-being, because households tend to *smooth* their consumption so as to maintain a stable standard of living over time (Rogers and Gray, 1994; Slesnick, 2001).

Private transport expenditures include purchases of cars and two-wheelers, insurance costs for cars and two-wheelers, purchases of fuels, lubricants, tyres and accessories, maintenance and repair costs, parking costs, lock-up garage or parking-lot rental costs, car licence and annual registration taxes, and vehicle-use-related fines.

To understand some of the differences between the countries in our sample as regards transport expenditures and their effect on inequality, some background information is necessary about vehicle taxation systems in each country[2].

In France, the VAT rate on automobile purchases was as high as 33.33% until 1987. It then gradually decreased: 28% in Sep. 1987, 25% in Sep. 1989, 22% in Sep. 1990, and 18.6% (rate imposed on the majority of commodities) in April 1991. As for most products, the rate increased to 20.6% in August 1995, then decreased to 19.6% since April 2000. A car registration tax is paid when a vehicle is bought, whether new or second-hand; it is also paid when changing residential location from a prefecture to another. The tax is calculated on the basis of engine size expressed in fiscal horsepower. The tax rate per horsepower is fixed at the province level. In 1995, this rate varied between 95 FF (about 14.5 EUR) and 195 FF (about 19.7 EUR). In 2008, it ranged from 27 EUR to 46.15 EUR. Besides, there is an annual tax on ownership of a vehicle (this tax is no more imposed on households from 2001 on) and taxes on insurance. As for fuels, the domestic tax on petroleum products (TIPP) and VAT (19.6%) apply.

The structure of taxes and duties put on the car in Denmark is exceptionally complex. There have been many attempts to alter the taxation of private vehicles to obtain more energy-efficient car transport. The last significant reform was completed in 1997. The most important objective was to reduce taxes on car ownership and simultaneously increase taxes on car use by increasing petrol duties. However, the price of new cars in Denmark is much higher than in other countries due to the high vehicle registration fee. For example, the registration tax in 2003 (charged on the basis of the retail price) is 105% of the first 7,653 EUR of the value and 180% of the remainder! In addition, all cars are subject to VAT at 25%. Besides an annual road tax, a supplementary tax is also imposed on vehicles using fuel other than gasoline. All motor fuels are subject to VAT (25%).

Car taxation in Cyprus has changed several times during the last two decades. Prior to the year 2003 registration taxes and annual vehicle taxes were calculated on the basis of vehicle weight and were higher for diesel powered cars; from 2003 onwards taxes are based on engine size regardless of the fuel they use, and are further differentiated according to carbon dioxide emissions (with low $CO_2$ cars enjoying tax reductions and high $CO_2$ cars bearing an additional tax penalty). Tax rates have changed again in the year 2006. As regards second-hand cars, their current tax levels, also calculated on the basis of engine size, decrease with age. Regarding fuel taxes, the major difference between the two survey years was VAT. This tax was introduced only from 1992 onwards at the rate of 5%; its rate was of 15% in 2003. In 1991, the excise tax was 0.1048 Cyprus pounds per litre (0.18 eurocents per litre), for both petrol and diesel fuel. This was 0.1748 Cyprus pounds per litre (0.30 eurocents per litre) in 2003.

Table 1 presents the expenditure shares for private transport in the three countries. The average expenditure devoted by French households to private transport (mainly car acquisition and use expenses) remained stable at about 14% of the total budget and then decreased slightly since the mid-1990s. However, this share differs greatly according to the

[2] A detailed account of taxation systems in France and Denmark is provided, for example, by Bückman and Rienstra (1998).

standard of living and grows with income: the gap between the first and last quintiles is up to 9 percentage points.

**TABLE 1 Budget Shares of Private Transport**

| Quintile ∗ | **France** | | | **Cyprus** | | **Denmark** | |
|---|---|---|---|---|---|---|---|
| | 1979 | 1989 | 2000 | 1991 | 2003 | 1997 | 2005 |
| 1 | 7.2<br>[6.8; 7.6] | 8.3<br>[7.8; 8.7] | 8.1<br>[7.7; 8.5] | 9.4<br>[8.5; 10.3] | 8.6<br>[7.8; 9.4] | 7.0<br>[6.0; 8.1] | 7.6<br>[6.3; 8.9] |
| 2 | 10.9<br>[10.4; 11.5] | 10.7<br>[10.2; 11.2] | 9.9<br>[9.4; 10.3] | 14.0<br>[12.7; 15.2] | 11.5<br>[10.5; 12.5] | 7.5<br>[6.4; 8.6] | 11.9<br>[9.9; 13.9] |
| 3 | 12.5<br>[11.9; 13.1] | 13.0<br>[12..3; 13..6] | 11.8<br>[11.3; 12.4] | 16.8<br>[15.3; 18.3] | 13.4<br>[12.2; 14.5] | 9.8<br>[8.4; 11.3] | 13.4<br>[11.2; 15.6] |
| 4 | 15.2<br>[14.5; 15.8] | 15.7<br>[14.9; 16.4] | 14.0<br>[11.4; 14.6] | 23.2<br>[21.2; 25.3] | 13.7<br>[12.5; 14.8] | 17.9<br>[15.3; 20.5] | 15.8<br>[13.2; 18.3] |
| 5 | 15.1<br>[14.4; 15.7] | 16.9<br>[16.0; 17.8] | 12.2<br>[11.6; 12.8] | 25.1<br>[22.7; 27.4] | 20.0<br>[18.2; 21.7] | 29.8<br>[25.5; 34.2] | 25.1<br>[21.3; 29.0] |
| **All hhs.** | **13.5**<br>**[13.2; 13.8]** | **14.4**<br>**[14.0; 14.7]** | **11.9**<br>**[11.6; 12.3]** | **21.3**<br>**[20.2; 22.3]** | **15.3**<br>**[14.6; 15.9]** | **17.6**<br>**[16.4; 18.9]** | **17.0**<br>**[15.7; 18.3]** |

Sources: Household expenditure surveys.

∗ Quintiles of total expenditure by consumption unit (Oxford scale).

Note: Confidence intervals at 95% are given in square brackets.

The same patterns can be observed in Denmark and Cyprus, but with notably larger budget shares. The gap between the first and last quintiles is even higher in these two countries, particularly in Denmark where it reached 23 percentage points in 1997. This reflects the structuring of household automobile equipment by their income level, even though car diffusion progressed over the period: as shown in Table 2 below, the number of cars per household increased more strongly for the lowest incomes. Table 1 displays also a considerable decline of the budget share of private transport in Cyprus. This is mainly due to a decrease in car purchase costs after 1993, following a relaxation of restrictions on imports of second-hand cars: the maximum allowable age of an imported vehicle was raised from two to five years. Consequently, from 1993 onwards, second-hand cars constituted the majority of new car registrations in the country. Moreover, new cars became cheaper too: Clerides (2008) found evidence of a 5-10% drop in the real price of new automobiles as a result of this regulatory change.

Table 2 provides interesting insights of vehicle ownership levels depending on the standard of living. In the case of Denmark, the large differences according to income are largely due to the effect of heavy taxes imposed on automobiles, making cars affordable only to households with relatively high incomes. These high car costs can also explain the very low overall levels of car ownership, as compared to Cypriot and French households.

**TABLE 2 Number of vehicles per household**

| Quintile * | France | | | Cyprus | | Denmark | |
|---|---|---|---|---|---|---|---|
| | 1979 | 1989 | 2000 | 1991 | 2003 | 1997 | 2005 |
| 1 | 0.43 | 0.60 | 0.72 | 0.37 | 0.65 | 0.45 | 0.56 |
| 2 | 0.75 | 0.93 | 1.08 | 1.02 | 1.26 | 0.58 | 0.85 |
| 3 | 0.93 | 1.08 | 1.23 | 1.20 | 1.57 | 0.77 | 0.98 |
| 4 | 1.07 | 1.18 | 1.36 | 1.36 | 1.81 | 0.94 | 0.96 |
| 5 | 1.13 | 1.29 | 1.42 | 1.59 | 1.88 | 1.11 | 1.13 |
| **All hhs.** | **0.86** | **1.02** | **1.16** | **1.11** | **1.43** | **0.77** | **0.90** |

Sources: Household expenditure surveys.
* Quintiles of total expenditure by consumption unit (Oxford scale).

Coming to the budget share of public transport, illustrated in Table 3, this is very low, particularly in France and Cyprus. The decline in budget shares in Cyprus is mainly due to the fact that public transport modes (buses) have almost disappeared in the country between the two survey years 1991 and 2003: according to official statistics, the total number of passengers has decreased by 50% during this period, and currently public transport accounts for 1.8% of total trips and 2.7% of total passenger kilometres travelled (CYSTAT, 2008). Rising incomes, urban sprawl and – most importantly – lack of investments in public transport infrastructure are responsible for this decline of bus transport.

In general, there is no regular pattern related to income level, probably because of a diversity of contexts in terms of urbanisation and population density, and hence as to the availability of local public transport means.

**TABLE 3 Budget Shares of Public Transport**

| Quintile * | France | | | Cyprus | | Denmark | |
|---|---|---|---|---|---|---|---|
| | 1979 | 1989 | 2000 | 1991 | 2003 | 1997 | 2005 |
| 1 | 0.78<br>[0.74 ; 0.82] | 0.98<br>[0.93 ; 1.03] | 0.85<br>[0.81 ; 0.89] | 3.09<br>[2.78 ; 3.40] | 0.84<br>[0.76 ; 0.92] | 3.96<br>[3.35 ; 4.57] | 3.32<br>[2.76 ; 3.88] |
| 2 | 0.91<br>[0.87 ; 0.95] | 0.81<br>[0.77 ; 0.85] | 0.84<br>[0.80 ; 0.88] | 2.24<br>[2.04 ; 2.44] | 1.05<br>[0.96 ; 1.14] | 3.76<br>[3.21 ; 4.31] | 2.26<br>[1.88 ; 2.64] |
| 3 | 0.99<br>[0.99 ; 1.03] | 0.93<br>[0.88 ; 0.98] | 0.94<br>[0.90 ; 0.98] | 1.98<br>[1.80 ; 2.16] | 1.07<br>[0.98 ; 1.16] | 3.40<br>[2.90 ; 3.90] | 2.59<br>[2.17 ; 3.01] |
| 4 | 1.10<br>[1.05 ; 1.15] | 1.07<br>[1.02 ; 1.12] | 1.13<br>[1.08 ; 1.18] | 1.85<br>[1.69 ; 2.01] | 1.25<br>[1.14 ; 1.36] | 3.23<br>[2.76 ; 3.70] | 3.64<br>[3.05 ; 4.23] |
| 5 | 1.39<br>[1.33 ; 1.45] | 1.35<br>[1.28 ; 1.42] | 1.18<br>[1.12 ; 1.24] | 1.69<br>[1.53 ; 1.85] | 1.32<br>[1.20 ; 1.44] | 3.32<br>[2.83 ; 3.81] | 3.22<br>[2.72 ; 3.72] |
| **All hhs.** | **1.14**<br>**[1.11 ; 1.17]** | **1.10**<br>**[1.07 ; 1.13]** | **1.06**<br>**[1.03 ; 1.09]** | **1.91**<br>**[1.82 ; 2.00]** | **1.19**<br>**[1.14 ; 1.24]** | **3.45**<br>**[3.20 ; 3.70]** | **3.06**<br>**[2.82 ; 3.30]** |

Sources: Household expenditure surveys.
* Quintiles of total expenditure by consumption unit (Oxford scale).
Note: Confidence intervals at 95% are given in square brackets.

## 4. CONSUMPTION INEQUALITIES AND REDISTRIBUTIVE EFFECTS OF TAXES

Transport expenditures are grouped into sufficiently homogeneous categories: automobile purchases, two-wheeler purchases, fuels, other vehicle use items, and public transport. The results in this section are presented for these categories as well as in aggregate form.

To account for household composition, all estimations were carried out on the basis of expenditures per consumption unit (as defined in the Oxford scale). In the estimations, the data were weighted by the respective survey weights of the households. The estimators of all the parameters of the decomposition of the Gini coefficient are efficient (i.e., asymptotically unbiased), and their distributions converge to a normal distribution (Schechtman and Yitzhaki, 1987). Thus, estimation of their standard errors allows constructing confidence intervals according to values of a normal distribution. Standard errors are estimated with the *jackknife* method. For a random variable $X$ observed on a sample of size $n$, the *jackknife* estimation of the standard error of an estimator $\hat{\theta}(X)=\hat{\theta}(X_1,\dots,X_n)$ goes through two stages (see e.g. Efron and Gong, 1983):

(1) estimation of $n$ values $\hat{\theta}_{(i)}(X)$, $i=1,\dots,n$, where $\hat{\theta}_{(i)}(X)$ is $\hat{\theta}(X)$ calculated after deleting observation $X_i$ (i.e., based on $n-1$ observations) ;

(2) utilisation of the $n$ values $\hat{\theta}_{(i)}(X)$ to estimate the standard error of $\hat{\theta}(X)$ by

$$\left[\frac{n-1}{n}\sum_{i=1}^{n}\left(\hat{\theta}_{(i)}(X)-\bar{\hat{\theta}}_{(\bullet)}(X)\right)^2\right]^{1/2},$$

where $\bar{\hat{\theta}}_{(\bullet)}(X)$ is the average of $\hat{\theta}_{(i)}(X)$, $i=1,\dots,n$.

Before examining the estimation results, it is worth noting certain characteristics of the data used. First, the observed expenditures are the result of choices made under income and price constraints. Moreover, by their nature, some goods and services are not purchased in a frequent and regular manner (e.g. durables). Likewise, some expenditures are conditional to others or to the existence of a stock of durables, as is the case with vehicle use expenditures. Finally, at household level certain expenditures may be insufficiently recorded because of the survey method and/or the observation period.

The effect of these aspects on the estimations appears, notably, through the more or less large frequency of zero expenditures in the sample. The level of a Gini coefficient indicates the degree of disparities between households in terms of expenditures on a category of goods and/or services. These disparities reflect differences in terms of amounts spent as well as how widespread these expenditures are among households. In general, as Garner (1993, p. 137) points out, the greater is the proportion of zero expenditures, whether as a result of consumer choice or due to the method of observation, the higher is the corresponding Gini index.

### 4.1. Inequalities and Redistributive Effects

#### *4.1.1. Inequalities by Expenditure Item and their Contribution to Overall Inequality*

Table 4 presents the estimated Gini coefficients for each one of the household surveys used in this study. The lowest Gini coefficients are observed in the categories of expenditures on vehicle use (fuels and other items). This is not surprising because vehicle use expenditures are increasingly widespread in the population with rising car ownership over the years. Then come, in ascending order, the Gini indices of expenditures on public transport and on car purchases. Finally, two-wheeler purchases exhibit the highest concentration. This can be explained by the relative scarcity of these purchases. For instance, they represent on average about 1% of the transport budget among French households, and 0.2% of their total budget.

**TABLE 4 Gini Coefficients by Expenditure Item**

| Expenditure item | France | | | Cyprus | | Denmark | |
|---|---|---|---|---|---|---|---|
| | 1979 | 1989 | 2000 | 1991 | 2003 | 1997 | 2005 |
| Private transport | 0.671 [0.664; 0.679] | 0.668 [0.662; 0.675] | 0.643 [0.636; 0.650] | 0.698 [0.685; 0.712] | 0.601 [0.585; 0.617] | 0.704 [0.726; 0.682] | 0.617 [0.588; 0.646] |
| Veh. purchases | 0.897 [0.892; 0.902] | 0.883 [0.878; 0.888] | 0.895 [0.890; 0.900] | 0.891 [0.881; 0.902] | 0.916 [0.908; 0.924] | 0.901 [0.886; 0.916] | 0.897 [0.877; 0.917] |
| Automobiles | 0.905 [0.900; 0.910] | 0.888 [0.883; 0.894] | 0.902 [0.897; 0.907] | 0.893 [0.882; 0.903] | 0.919 [0.911; 0.927] | 0.912 [0.896; 0.927 ] | 0.910 [0.890; 0.931] |
| 2-wheelers | 0.956 [0.949; 0.962] | 0.977 [0.973; 0.980] | 0.972 [0.968; 0.975] | 0.987 [0.975; 0.999] | 0.993 [0.991; 0.995] | 0.976 [0.960; 0.992] | 0.931 [0.907; 0.955] |
| Fuels | 0.645 [0.635; 0.654] | 0.579 [0.571; 0.587] | 0.571 [0.563; 0.579] | 0.564 [0.547; 0.581] | 0.472 [0.459; 0.486] | 0.652 [0.624; 0.679] | 0.620 [0.586; 0.655] |
| Other use exp. | 0.690 [0.676; 0.704] | 0.648 [0.636; 0.660] | 0.644 [0.628; 0.659] | 0.530 [0.515; 0.546] | 0.450 [0.437; 0.462] | 0.594 [0.563; 0.624] | 0.508 [0.471; 0.544] |
| Public transport | 0.889 [0.881; 0.897] | 0.882 [0.870; 0.894] | 0.862 [0.851; 0.873] | 0.777 [0.764; 0.789] | 0.791 [0.780; 0.802] | 0.679 [ 0.646; 0.711] | 0.714 [0.684; 0.745] |
| *All transport* | *0.644 [0.637; 0.652]* | *0.638 [0.631; 0.645]* | *0.617 [0.610; 0.625]* | *0.658 [0.644; 0.672]* | *0.578 [0.562; 0.594]* | *0.611 [0.587; 0.636]* | *0.541 [0.512; 0.569]* |
| **Total expend.** | **0.338 [0.333; 0.344]** | **0.336 [0.329; 0.343]** | **0.356 [0.348; 0.365]** | **0.397 [0.385; 0.409]** | **0.306 [0.298; 0.315]** | **0.224 [0.212; 0.236]** | **0.222 [0.206; 0.238]** |

Sources: Household expenditure surveys.
Note: Confidence intervals at 95% are given in square brackets.

Except for the case of vehicle purchases for which there is no regular temporal pattern (probably because purchases of durables are not made frequently), Table 4 shows that inequalities have generally decreased in all countries over time. In particular, there has been a steady decrease in the case of expenditures on fuels and other vehicle use items.

The contribution of each transport expenditure category to the overall inequality in a country is displayed in Table 5. As equation (6) shows, the contribution of a component to overall inequality is determined by three factors: the proper inequality of the component (measured by its Gini coefficient), its degree of association with total expenditure (measured by their Gini correlation), and its weight in the total budget. Thus, despite a very high Gini coefficient (close to 1), the relative contribution of two-wheeler purchases to overall inequality is insignificant in all three countries, due to their small budget share and their weak association with total expenditure. By contrast, the relative contribution of car purchases is much more important in all countries (ranging from 8% to 27%) despite slightly lower Gini coefficients; this is due to greater budget shares and stronger correlation with total expenditure. In terms of significance for overall inequality, this component is followed by vehicle use expenditures other than fuels, then by fuels, and finally by expenditures on public transport. In the case of France, inequalities among households regarding transport as a whole are essentially attributable to automobile purchases (44% to 58% depending on the survey period), followed by vehicle use expenditures other than fuels (21% to 26%) and fuels (13% to 22%). The contribution of public transport is more modest (6% to 8%). That of two-wheelers expenditures is even lower (less than 2%). Over the whole observation period, the contribution to overall inequality declines in the case of fuels and of the remaining vehicle use expenditures. It also declines slightly for public transport. The contribution of two-wheelers purchases remains stable at a negligible level. The contribution of transport as a whole decreases at the end of the period after a slight increase, thus following the trend of the most important of its components (car purchases).

**TABLE 5 Relative Contribution to Overall Inequality (%)**

| Expenditure item | France | | | Cyprus | | Denmark | |
|---|---|---|---|---|---|---|---|
| | 1979 | 1989 | 2000 | 1991 | 2003 | 1997 | 2005 |
| Private transport | 16.5<br>(0.41) | 18.4<br>(0.50) | 13.4<br>(0.42) | 28.1<br>(1.3) | 22.3<br>(1.0) | 40.9<br>(3.40) | 31.6<br>(3.02) |
| Vehicle purchases | 7.7<br>(0.28) | 11.7<br>(0.42) | 7.9<br>(0.32) | 22.0<br>(1.3) | 15.3<br>(1.0) | 30.0<br>(3.29) | 21.2<br>(2.86) |
| Automobiles | 7.6<br>(0.28) | 11.4<br>(0.42) | 7.8<br>(0.32) | 21.8<br>(1.3) | 15.1<br>(1.0) | 27.3<br>(3.13) | 20.8<br>(2.87) |
| Two-wheelers | 0.1<br>(0.03) | 0.2<br>(0.04) | 0.2<br>(0.03) | 0.2<br>(0.17) | 0.2<br>(0.09) | 2.7<br>(1.15) | 0.4<br>(0.15) |
| Fuels | 3.9<br>(0.12) | 2.6<br>(0.07) | 2.1<br>(0.07) | 2.8<br>(0.2) | 3.5<br>(0.1) | 3.7<br>(0.37) | 4.5<br>(0.57) |
| Other use exp. | 4.9<br>(0.26) | 4.2<br>(0.19) | 3.3<br>(0.21) | 3.3<br>(0.2) | 3.5<br>(0.1) | 7.2<br>(0.67) | 5.9<br>(0.76) |
| Public transport | 1.7<br>(0.13) | 1.6<br>(0.18) | 1.4<br>(0.13) | 1.5<br>(0.1) | 1.4<br>(0.1) | 2.8<br>(0.75) | 3.5<br>(0.63) |
| *All transport* | *18.2*<br>*(0.42)* | *20.1*<br>*(0.50)* | *14.7*<br>*(0.45)* | *29.6*<br>*(1.3)* | *23.6*<br>*(1.0)* | *43.6*<br>*(3.31)* | *35.1*<br>*(2.91)* |

Sources: Household expenditure surveys.
Note: Standard errors are given in brackets.

Similar trends show up in the cases of Cyprus and Denmark. The notable differences lie in the greater contribution of car-related components to global inequality, especially car purchases. This contribution is highest for Denmark, as expected in view of the very high motoring costs.

*4.1.2. Redistributive Effects of Taxes by Expenditure Item*

Table 6 displays the estimated effect on overall inequality (i.e. inequality of total expenditure) of a marginal change in each transport expenditure item. In the case of France, it turns out that taxes on transport commodities as a whole remain progressive, though to a lesser extent in 2000 than earlier: a 1% proportional increase of transport expenditures would have reduced global inequality by 2% in the early 2000’s (compared to 5% previously). The progressivity of taxes on transport as a whole is mainly due to the progressive character of taxes on car purchases, strongly linked to income and with a higher budget share than for the other expenditure items. However, with the diffusion of the automobile and of its use, taxes on vehicle use items are less and less progressive and become even regressive in the case of fuels. Though the extent of the induced variations is very small (the relative marginal effect decreased from 0.1% to -1%), the trend is important: it reflects a gradual transformation of the distributions of these expenditures with the growing penetration of cars in the population. The slightly progressive character of taxes on public transport services is to be attributed to long distance trips. Indeed, as shown in (Berri, 2005), taxes on local public transport appear to be neutral at national level (i.e. neither progressive nor regressive). However, this result conceals a diversity of local conditions in terms of supply of these transport means according to the degree of urbanization and population density. Effectively, these taxes prove to be regressive when focusing on the Greater Paris region, a large urban area very well endowed with public transport infrastructure. As regards purchases of two-wheelers, which are rare, there seems to be no effect whatsoever on global inequalities.

**TABLE 6 Change in Overall Inequality due to a Marginal Change in a Component (%)**

| Expenditure item | France | | | Cyprus | | Denmark | |
|---|---|---|---|---|---|---|---|
| | 1979 | 1989 | 2000 | 1991 | 2003 | 1997 | 2005 |
| Individual transport | 4.0 | 4.9 | 1.9 | 7.4 | 7.5 | 23.2 | 14.6 |
| Vehicle purchases | 3.0 | 5.1 | 2.9 | 9.3 | 8.7 | 20.4 | 13.9 |
| Automobiles | 3.0 | 5.1 | 3.0 | 9.3 | 8.6 | 18.6 | 13.9 |
| Two-wheelers | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 1.8 | 0.0 |
| Fuels | 0.1 | -0.6 | -1.0 | -1.0 | -0.6 | 1.0 | 0.9 |
| Other use exp. | 0.9 | 0.3 | -0.1 | -1.0 | -0.5 | 1.9 | -0.2 |
| Public transport | 0.4 | 0.4 | 0.2 | -0.5 | 0.2 | -0.7 | 0.5 |
| *All transport* | *4.4* | *5.3* | *2.1* | *6.9* | *7.7* | *22.5* | *15.1* |

Sources: Household expenditure surveys.

The (Gini) elasticities with respect to total expenditure, as shown in Table 7, confirm the above conclusions as to the regressive (elasticity < 1) or progressive (elasticity > 1) character of a tax on a category of expenditures.

**TABLE 7 Total Expenditure (Gini) Elasticities – France**

| Expenditure item | 1979 | 1989 | 2000 |
|---|---|---|---|
| Individual transport | 1.318 [1.280 ; 1.356] | 1.358 [1.317 ; 1.399] | 1.165 [1.122; 1.208] |
| Vehicle purchases | 1.635 [1.577 ; 1.692] | 1.779 [1.720 ; 1.839] | 1.588 [1.526; 1.650] |
| Automobiles | 1.668 [1.609 ; 1.727] | 1.797 [1.737 ; 1.857] | 1.616 [1.553 ; 1.680] |
| Two-wheelers | 0.809 [0.534 ; 1.084] | 1.155 [0.920 ; 1.389] | 0.860 [0.684 ; 1.036] |
| Fuels | 1.020 [0.977 ; 1.062] | 0.817 [0.780 ; 0.854] | 0.688 [0.651 ; 0.725] |
| Other use exp. | 1.228 [1.154 ; 1.301] | 1.083 [1.023 ; 1.143] | 0.975 [0.898 ; 1.055] |
| Public transport | 1.364 [1.243 ; 1.485] | 1.346 [1.179 ; 1.513] | 1.215 [1.088 ; 1.342] |
| *All transport* | *1.322 [1.287 ; 1.357]* | *1.357 [1.318 ; 1.395]* | *1.169 [1.127 ; 1.212]* |

Sources: Household expenditure surveys.
Note: Confidence intervals at 95% are given in square brackets.

Thus, the luxury character of transport commodities as a whole is obvious (with an elasticity of 1.32 in 1979, 1.36 in 1989 and 1.17 in 2000), because of the predominance of car purchases (the elasticity of which ranges between 1.6 and 1.8). Vehicle use expenditures show continuously decreasing elasticities (from 1 to 0.7 for fuels and from 1.2 to 1 for the remaining vehicle use items), thus confirming the more and more necessary character of the car. The same decreasing tendency is observed for the elasticity of public transport (from 1.4

to 1.2). However, as mentioned previously, these elasticities give information on the *sign* of the relative marginal effect, but not on its *magnitude*.

Although the results are qualitatively similar in the two other countries, there are significant differences in magnitudes. The largest contrast is between Denmark and France. The progressivity of taxes on car purchases is much stronger in Denmark. As pointed out earlier, these taxes are so high that car purchase costs can be afforded only by high incomes. Given the higher share of car purchases in the total budget as compared to other transport components, taxes on all transport are also much more progressive. Also, fuel taxes are still progressive in this country. Cyprus shows intermediate figures: in particular, taxes on fuels are slightly regressive and the impact on overall inequality is of the same order of magnitude as for France.

## 5. CONCLUSIONS AND IMPLICATIONS FOR TRANSPORT POLICY

Inequalities between households as regards the consumption of transport goods and services as well as the redistributive effects of taxes on various expenditure categories have been evaluated for three European countries. A decomposition by expenditure component of the Gini inequality index was applied, using individual-level data from repeated cross-sections of expenditure surveys spanning long time periods. The results highlight the effect of the gradual penetration of cars in the European population in the last decades.

Inequality regarding transport is mainly attributable to automobile purchases, followed by vehicle use items other than fuels, and fuels. The relative contribution of public transport is very small, due to a small budget share. The relative contribution of car use items decreased over time, thus reflecting the increasingly widespread use of the car.

Taxes on transport goods and services as a whole are progressive, i.e. they affect the rich more than the poor. However, this is principally due to the progressivity of taxes on automobile purchases, strongly linked to income and with a high budget share as compared to the remaining types of expenditures. On the contrary, taxes on fuels are regressive (i.e., they affect the poor more than the rich) except in Denmark, whereas the progressive character of taxes on the other vehicle use goods and services has become weaker over the years. This, again, is an evidence of the effect of the diffusion of the car, becoming more and more of a necessity rather than a luxury.

The above findings, more or less typical of socio-economic conditions in all European countries, offer some interesting policy implications. Policy makers should not ignore equity issues when considering measures to attenuate the environmental impact of cars (pollutant emissions, congestion and noise) in order not to worsen social inequalities. Increasing car use costs, notably fuel prices, through an increase of uniform taxes would be particularly inequitable. In particular, the least wealthy of car-dependent households living in low-densely populated zones would face a heavy burden that they cannot avoid. Indeed, as shown by the example of the Greater Paris region (Berri, 2007), the peripheral location of modest income households, because of high property prices in the centre of the urban area, involves transport expenditures (mainly car purchase and running costs) that increase with distance from the centre. These expenditure levels are not necessarily chosen, but are induced by the absence of a credible alternative to the car. McCann *et al.* (2000) show similar patterns in the case of American urban areas. The drift towards remote areas is in particular favoured by the fact that mortgage lenders do not take account of transport expenditures when awarding home purchase loans (Bardy, 2001; Hare, 1995). By so doing, they consider that life in the outskirts (where land and property prices are lower, but badly served by public transport) is more affordable than in the centre.

Area-specific measures may be more appropriate. In the case of dense urban areas, urban tolls and restrictions of access are examples of such measures. In parallel, public transport supply has to be improved in terms of lines of service, speed, punctuality, comfort, etc. In addition, a global approach should include actions on the housing sector so as to increase the density of the urban fabric and attenuate the sprawl tendency. Besides the necessity of taking into account transport costs in the evaluation of solvency, measures improving the housing market conditions may consist of stimulating construction and promoting low-cost accommodation in most accessible zones by public transport.

## ACKNOWLEDGEMENTS

The authors are grateful to Prof. Shlomo Yitzhaki (Hebrew University of Jerusalem and Central Bureau of Statistics, Israel) for kind permission to use the programme Jackknife1612 (version of August 2001) for estimation of the Gini coefficient and other parameters resulting from its decomposition. Sotiroulla Hadjispyrou has offered excellent assistance in extracting and processing data from the Cypriot household surveys. The authors also thank Dr. Jean-Loup Madre (INRETS-DEST) for helpful comments and suggestions.

## REFERENCES

Atkinson, A. B. (1970). On the measurement of inequality, *Journal of Economic Theory*, 2, pp. 244-263.

Bardy, J.-P. (2001). *La prise en compte des dépenses de transports dans les projets d'accession : l'approche des organismes financiers*, report of the Association Départementale d'Information sur le Logement de Paris (ADIL 75) for the Direction Régionale de l'Equipement d'Ile-de-France (DREIF), 130 p.

Berri, A. (2007). Residential location and household expenditures for transport and housing: the example of the Greater Paris region, *11th World Conference on Transport Research, 24-28 June, Berkeley, CA* (CD-ROM).

Berri, A. (2005). *Dynamiques de la motorisation et des dépenses de transport des ménages. Analyses sur données individuelles et semi-agrégées*, PhD thesis, Université de Paris 1 – Panthéon-Sorbonne.

Bückman, E. H., and S. A. Rienstra (eds.) (1998). *EUROFISC: Comparison of fiscal measures in passenger transport – Country essays*, Dutch Ministry of Transport, 103 p.

Clerides, S. (2008). Gains from trade in used goods: evidence from automobiles, *Journal of International Economics*, Vol. 76, No. 2, pp. 322-336.

CYSTAT, Statistical Service of the Republic of Cyprus (2008), *Short Distance Passenger Mobility Survey in Cyprus 2007*, Nicosia, Cyprus.

Deaton, A. (1997). *The analysis of household surveys: a microeconometric approach to development policy*, The Johns Hopkins University Press, Baltimore.

Efron, B., and G. Gong. (1983). A leisurely look at the bootstrap, the jackknife, and cross-validation, *The American Statistician*, Vol. 37, No. 1, pp. 36-48.

Garner, T. I. (1993). Consumer expenditures and inequality: an analysis based on decomposition of the Gini coefficient, *Review of Economics and Statistics*, Vol. LXXV, No. 1, pp. 134-38.

Hare, P. H. (1995) *Clunker mortgages and transportation redlining: how the mortgage banking industry unknowingly drains cities and spreads sprawl*, Patrick H. Hare Planning and Design (Washington, DC), 21 p. <www.vtpi.org/clunker.pdf>

Lerman, R. I. (1999). How do income sources affect income inequality? In Silber, J. (ed.), *Handbook on income inequality measurement*, Kluwer Academic Publishers, Boston, pp. 341-362.

Lerman, R. I., and S. Yitzhaki (1994). Effect of marginal changes in income sources on U.S. income inequality, *Public Finance Quarterly*, Vol. 22, No. 4, pp. 403-417.

Lerman, R. I., and S. Yitzhaki (1989). Improving the accuracy of estimates of Gini coefficients, *Journal of Econometrics*, 42, pp. 43-47.

Lerman, R. I., and S. Yitzhaki (1985). Income inequality effects by income source: a new approach and applications to the United States, *Review of Economics and Statistics*, Vol. LXVII, No. 1, pp. 151-56.

Lerman, R. I., and S. Yitzhaki (1984). A note on the calculation and interpretation of the Gini index, *Economics Letters*, 15, pp. 363-68.

McCann, B. *et al.* (2000). *Driven to spend: the impact of sprawl on household transportation expenses*, joint report of the Surface Transportation Policy Project (Washington, DC) and the Center for Neighborhood Technology (Chicago, IL), 44 p. <www.transact.org/report.asp?id=36>

Olkin, I., and S. Yitzhaki (1992). Gini regression analysis, *International Statistical Review*, Vol. 60, No. 2, pp. 185-196.

Rogers, J. M., and M. B. Gray (1994). CE data: quintiles of income versus quintiles of outlays, *Monthly Labor Review*, Vol. 117, No. 12, pp. 32-37.

Schechtman, E., and S. Yitzhaki (1987). A measure of association based on Gini's mean difference, *Communications in Statistics – Theory and Methods*, Vol. 16, No. 1, pp. 207-231.

Sen, A. (1997). *On economic inequality*. Clarendon Press, Oxford [1973 edition, Oxford University Press, enlarged with an annex by J. FOSTER and A. SEN: "*On economic inequality* after a quarter century"].

Slesnick, D. T. (2001). *Consumption and social welfare. Living standards and their distribution in the United States*, Cambridge University Press, Cambridge.

Stark, O., J. E. Taylor, and S. Yitzhaki (1986). Remittances and inequality, *Economic Journal*, Vol. 96, No. 383, pp. 722-740.

Yitzhaki, S. (1997). The effect of marginal changes in prices on income inequality in Romania, *Research on Economic Inequality*, Vol. 7, pp. 241-258.

Yitzhaki, S. (1994). On the progressivity of commodity taxation, In Eichhorn, W. (ed.), *Models and measurement of welfare and inequality*, Springer-Verlag, Heidelberg, pp. 448-465.

**ANNEX**

## Gini Correlation

The Gini correlation between two random variables $X$ and $Y$ is a measure of their degree of association, based on the Gini Mean Difference (*11*). The Gini correlation coefficient is intermediate between the (usual) Pearson correlation coefficient and the rank-based Spearman correlation coefficient, the expressions of which are respectively

$$\rho(X,Y) = \operatorname{cov}(X,Y) \Big/ \sqrt{\operatorname{var}(X)\operatorname{var}(Y)} \text{ and}$$

$$r_S(X,Y) = \operatorname{cov}(R_X, R_Y) \Big/ \sqrt{\operatorname{var}(R_X)\operatorname{var}(R_Y)} .$$

$R_X$ and $R_Y$ represent the ranks according to the values of $X$ and $Y$, respectively. Divided by the size of the population or sample, they give the (empirical) cumulative distributions of the corresponding variables. Pearson correlation is based on the covariance of the two variables, whereas Spearman correlation is based on the covariance of their cumulative distributions. Gini correlation is a compromise between the two: it uses the covariance between one of the two variables and the cumulative distribution of the other. It is a non-symmetric measure and can take the two following forms:

$$R(X,Y) = \operatorname{cov}(X, G_Y(Y)) \big/ \operatorname{cov}(X, F_X(X)),$$

$$R(Y,X) = \operatorname{cov}(Y, F_X(X)) \big/ \operatorname{cov}(Y, G_Y(Y)).$$

In general, the two correlations $R(X,Y)$ and $R(Y,X)$ are not equal.

The properties of the Gini correlation coefficient combine properties of the Pearson and Spearman coefficients (*11*). Among these properties:

- for every $(X,Y)$, $-1 \le R(X,Y) \le 1$ ;
- if $X$ and $Y$ are independent, $R(X,Y) = R(Y,X) = 0$ ;
- if $Y$ is an increasing (resp. decreasing) monotone function of $X$, not necessarily linear, $R(X,Y)$ and $R(Y,X)$ will be equal to +1 (resp., -1); and
- if $(X,Y)$ has a bivariate normal distribution with parameters $\mu_X$, $\mu_Y$, $\sigma_X^2$, $\sigma_Y^2$ and $\rho$, then $R(X,Y) = R(Y,X) = \rho$.